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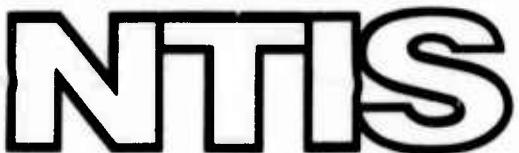
MOLDING HELMET LINERS FROM NYLON CLOTH
MADE FROM 1050 DENIER TYPE 700 NYLON
YARNS

Abraham L. Lastnik

Army Natick Laboratories
Natick, Massachusetts

1 July 1962

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CLOTHING & ORGANIC MATERIALS DIVISION

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Series Report No. 32

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ABSTRACT

Helmet liners were satisfactorily molded from 1 $\frac{1}{4}$ ounce, 2 x 2 basket-weave nylon fabric made of 1050 denier, 168 filaments, 3 - 4 \pm turns per inch, type 700 nylon yarn. These helmet liners satisfied the autoclave and the ballistic resistant requirements of Military Specification MIL-L-41800, Liner, Soldier's Steel Helmet, 1 May 1961.

MOLDING HELMET LINERS FROM NYLON CLOTH
MADE FROM 1050 DENIER TYPE 700 NYLON YARNS

I. Introduction

Liner, Soldier's Steel Helmet, as specified in Military Specification MIL-L-41800, dated 1 May 1961, was type classified as Standard A for the Army at the Quartermaster Technical Committee Meeting No. 8-6, 25 October 1961.

The Quartermaster Research and Engineering Command is engaged in a continuous program to reduce the cost of the nylon helmet liner. As a result of a material development program, a substantial reduction has been effected in the molding time of the liner. The molding cycle was reduced from approximately 20 minutes to three minutes per unit by use of a catalyzed system composed of phenol formaldehyde and polyvinyl butyral resins. This reduction in molding time not only reduced labor costs, but it also increased productivity.

Flexible armor material for body armor and helmets conforms to the Military Specification MIL-C-12369, "Cloth, Nylon, Ballistic for Armor". This fabric is described as a 14 ounce, 2 x 2 basketweave made of Type 300 nylon yarn, 210 denier, 34 filament, 5 ply, 3 - 4 2 turns per inch. The Textile Engineering Section, Fibrous Materials Engineering Branch, Clothing & Organic Materials Division, recommended that a nylon fabric of standard ballistic cloth construction (2 x 2 basketweave) using 700 Type nylon yarn, 1050 denier, 168 filaments, 3 - 4 2 turns per inch, be substituted for the currently specified yarn. The proposed fabric meets the ballistic resistance criteria established in the military specification. Substitution of this fabric for the standard fabric would effect a calculated savings of approximately sixty three cents per running yard of 48 inch wide cloth.

This is a report on an effort to further reduce the cost of the nylon helmet liner by utilizing a fabric woven from lower cost higher tenacity nylon yarns than is now specified in MIL-C-12369 (QMC), 20 June 1961, "Cloth, Nylon, Ballistic for Armor".

II. Purpose

This study was undertaken to determine if Liners, Soldier's Steel Helmet, fabricated from nylon fabric made of 1058 denier, 168 filaments, 3 - 4 2 turns per inch, Type 700 nylon yarns, conform with MIL-L-41800, dated 1 May 1961.

III. Materials

1. Nylon Fabric: Standard construction (2 x 2 basketweave)

a. VEE-1169: 1050 denier, 168 filaments, 3 - 4 2 turns per

inch, 700 type nylon yarns, manufactured by West Point Manufacturing Company under Contract No. DAL9-129-QM-1490 in April 1961.

b. VE-1113: 1050 denier, 168 filaments, 3 - 4 2 turns per inch, 700 type nylon yarns, procured from West Point Manufacturing Company, February 1962.

c. Cloth, Nylon, Ballistic for Armor, conforming with Military Specification MIL-C-12369, constructed of 300 type nylon, 210 denier, 34 filaments, 5 ply, 3 - 4 2 turns per inch. This fabric procured against an early specification has a V50 ballistic limit of 1184 fps instead of the currently required 1250 fps.

2. Pigmented Resin

a. Resin-Basic formulation

Polyvinyl butyral solution	(25% solids)	868.0 pts/wt
Phenolic varnish	(57% solids)	100.0 pts/wt
Trimethylol Phenol	(60% solids)	267.0 pts/wt
Phthalic Anhydride		25.6 pts/wt
Methanol		51.2 pts/wt

b. Pigmented Solution

Basic Resin formulation		50.0 pts/wt
Ethanol		150.0 pts/wt
Olive Drab Pigment 13-Y271	5.0 pts/wt	
Cadmium Yellow Pigment 13-Y270	3.5 pts/wt	13.0 pts/wt

IV. Fabrication of Liner Shells

Coating of the nylon fabric and molding of the helmet liner shells were accomplished by DeBell and Richardson, Inc., under Contract No. DAL9-129-QM-1869.

1. Each of the three types of fabric samples were cut into 20 inch squares and spray coated with the pigmented resin solution, one side at a time. Each square was weighed before and after the coating to assure 15 - 18 percent resin content. The coated fabric was air dried to a tack-free state then precured in an air circulating oven at 280° F for 20 minutes.

2. The preforms were then cut, assembled into 4-ply structures, and packaged in polyethylene bags to prevent the resin coating from absorbing moisture prior to molding.

3. The helmet liner shells were molded of each fabric in a sequential order until five shells of each material were fabricated. The preform assembly was removed from the polyethylene bag, placed into the mold cavity, and the mold closed as quickly as possible. After 15 seconds, the mold was "gassed" three times in rapid succession. The total molding time - from initial close to final mold opening - was three minutes. After removal from the mold, the liners were cooled on a fixture to prevent distortion.

4. The helmet liner shells were molded in an 800 ton press using approximately 330 tons of molding force (1100 psi Hydraulic pressure behind a 27 inch diameter ram) and a mold surface temperature of 340-350° F.

V. Test Results

1. Ballistic Limit

Three helmet liner shells of each fabric were evaluated in accordance with paragraph 4.4.5 of MIL-L 41800. The two shells fabricated from the 700 type nylon satisfied the required minimum ballistic limit of 830 feet per second. The ballistic limits of the helmet shells are given in Table 1.

Table 1
BALLISTIC LIMIT OF HELMET LINER SHELLS MOLDED
FROM STANDARD AND EXPERIMENTAL
NYLON FABRICS
(V50 Limit in Feet Per Second)

<u>Firing Order/Fabric</u>	<u>VER110</u>	<u>VER1169</u>	<u>Standard*</u>
1	890		
2		871	
3			842
4	889		
5		834	
6			812
7	847		
8		898	
9			807
Average	875	868	820

*Ballistic limit lower than 830 fps required by specification probably due to nylon fabric used, see Materials, paragraph 1c. Ballistic limits of helmet liners resulting from a production test were equal to those obtained with the experimental cloth liners.

Ballistic evaluation was conducted by the Ballistic Materials Research Section, Materials Research Branch, Clothing and Organic Materials Division of the QM R&E Command.

2. Autoclaving

Helmet liner shells fabricated from the three fabric samples investigated were subjected to autoclaving for one-half (1/2) hour of saturated steam at a pressure of 17 + 1 pounds per square inch as specified in paragraph 4.4.4 of MIL-L-41800 showed no evidence of delamination, blistering, nor appreciable distortion.

VI. Discussion

The helmet liner specification stipulates that the cloth used for the inner and outer surface plies shall be dyed to match OG 106. The cloth used for all other plies need not be dyed. The resin used in all previous procurements was unpigmented. For this test, only white fabric was available.

The mold used for this evaluation was designed during a Quartermaster Corps contract that developed an integral and textured finish. It will produce a helmet liner that conforms with specification requirements except that painting and texturing will not be required. This integral finish is accomplished by laminating OG dyed nylon with pigmented resin in a stippled mold.

Because the test materials were white, it was decided to use pigmented resin to see if dyed material can be eliminated thereby effecting a further savings. The resulting helmets were colored olive green. Because the fabric used was white, the resulting uniform color was light and would not meet specified color standards. This, however, indicated the feasibility of eliminating the need for using dyed nylon provided the color of the pigmented resin was intensified.

Using pigmented resin and eliminating the dying requirement would reduce the cost of each helmet liner approximately twenty cents (\$.20). This would eliminate the dying operation and the special handling required to stack dyed and undyed plies of cloth.

VII. Conclusions

1. Helmet liner shells can be molded satisfactorily from 14 ounce, 2 x 2 basketweave fabric which employs 1050 denier, 168 filaments, 3 - 4 1/2 turns per inch, 700 type nylon yarns.

2. Helmet liner shells molded from 14 ounce, 2 x 2 basketweave nylon fabric which employs 1050 denier, 168 filaments, 3 - 4 1/2 turns per inch, 700 type nylon yarns satisfactorily meets the autoclaving and ballistic limit requirements of Military Specification MIL-L-41800, Liner, Soldier's Steel Helmet, dated 1 May 1961.

VIII. Recommendations

1. Modify Military Specification MIL-L-41800, Liner, Soldier's Steel Helmet, to permit the use of reinforcing material made of 14 ounce, 2 x 2 basketweave fabric made of 1050 denier, 168 filaments, 3 - 4 Z turns per inch, 700 type nylon yarn. The modification is estimated to effect a cost reduction of approximately sixty cents (\$.60) per helmet liner.
2. Institute a cost reduction program to develop a suitable pigmented resin so that helmets may be molded with an integrated Olive Green color without the use of dyed nylon fabric. If successful, a savings of approximately \$.20 per helmet can be effected.

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4. DeBell and Richardson, Incorporated, for the priority accorded this work and the expeditious accomplishment thereof.

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